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Vol. XXXVI MARCH, 1945 No. 3

The Journal of Educational Psychology

Devoted Primarily to the Scientific Study of Problems of Learning and Teaching

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$6.00 per Year · Published Monthly September to May

WARWICK & YORK, INC.
BALTIMORE, MD.

Entered as Second Class Matter Nov. 15, 1921, at the Post Office at Baltimore, Md. under the Act of March 3, 1879; additional entry as Second Class Matter at York, Pa.

THE JOURNAL OF Educational Psychology

Established 1910

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Manuscripts should be typed and double-spaced throughout including quotations, footnotes, and references. Return postage should be included with all unsolicited manuscripts.

THE JOURNAL is published monthly from September to May. The price per year in the United States and Pan-American countries is $6.00; $6.20 to Canada; and $6.40 to other foreign countries. Part-year subscriptions are 90 cents per issue ordered. Back volumes are $7.00 each, and back issues $1.10.

Subscribers should notify the Publishers of change of address at least four weeks in advance of publication of issue with which the change is to take effect. Claims for non-receipt of an issue will not be honored unless made within two weeks after receipt of next succeeding number.

WARWICK AND YORK *Publishers* BALTIMORE, MD.

THE JOURNAL OF
EDUCATIONAL PSYCHOLOGY

Volume XXXVI March, 1945 Number 3

VERTICAL ROTATION IN VISUAL-MOTOR PERFORMANCE—ITS RELATIONSHIP TO READING REVERSALS

A. A. FABIAN*

Bellevue Psychiatric Hospital

REVERSALS

Children learning to use written language symbols frequently reverse those that have similar configurations. As they advance in the reading program, reversal errors in reading and transcription are usually corrected, but in a small percentage of children this confusion of symbols remains. The literature is replete with theories which have been advanced to explain the reversal tendency and the reason for its persistence.

Mechanical.—An example of mechanical interference is Monroe's[1] theory that children who are dominantly left-eyed may find their vision obstructed by the bridge of the nose when sighting from left to right. There is a tendency then, she believes, for the visual sweep to be in the opposite (right to left) direction and, therefore, for reversal errors. It is difficult to concede to this impression, especially since reversals occur even when single symbols are copied as well as with words and sentences read at such a distance as to preclude obstruction in vision.

Physiological.—Disturbances in optical and in cortical physiology have been proposed for the etiology of sinistro-dextrad inversion and other perceptual distortions. Betts[2] states that widening of the inter-ocular distance is greatest between the ages of six and seven. Poor ocular convergence resulting from

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this developmental peculiarity as well as visual refraction errors due to other causes are the factors emphasized by Betts and other investigators[3] as responsible for visual distortions so common to the beginning reader. On the other hand there are numerous studies[4] which minimize the importance of peripheral visual defects.

A similar controversy revolves about the question of the significance of eye movement in reading retardation and reversals. Eye movement studies, the earliest approach to the physiology of reading, are still in use in many reading clinics where photographic records are routinely made. Regression, or backward sweep of the eyes, which characterizes those handicapped in reading, is believed to be responsible for the reversal tendency. Tinker,[5] who has comprehensively reviewed the subject, cites many authorities who agree with him that eye movements are effects and not causes of reading difficulties.

It is natural that reading disability, falling into the domain of visual performance, should engage the attention of eye specialists. Hinshelwood,[6] an opthalmologist, was one of the first to investigate the problem from the medical point of view. However, he too concluded that a central brain defect in the area subserving vision was responsible for the perceptual errors rather than a disorder of peripheral optics. Although pathological studies have thus far failed to corroborate Hinshelwood's hypothesis, a neuro-physiological theory which stresses the influence of central cortical activity has received wider acceptance. Orton[7] regards the reversal tendency as evidence of the failure of one cerebral hemisphere to assert its dominance over the other, with the result that mirror image engrams posited in both are confused. This is an attractive theory which has many protagonists who demonstrate mixed eye-hand preference in poor readers as signs of mixed cerebral dominance. Dearborn[8] asserts, as did Javal,[9] that left-handedness is conducive to mirror-writing.

Psychophysical.—The problem of configurational distortion in perception has been studied by Gestalt psychologists. The results of their experiments in rotation in the visual field are pertinent to the question of reversals. They stress the fact that visual perceptions of children differ considerably from those of adults. Children are inclined to ignore details or to isolate insignificant fragments as configurational wholes unrelated to

the rest of the field. In some ways gestalt forces such as closure and proximity seem more compelling in children and tend to make perception vague and inaccurate. Bender,[10] in studying clinically the maturation of gestalt function, has emphasized the influence of motor behavior which is integrated with sensory perception elements in visual-motor development. She has also demonstrated regressive features including rotational tendencies in various psychopathological and organic conditions. This would imply that figure ground distortions are developmental vestiges which gradually disappear but which may recur or be retained if the central nervous system is damaged or the total personality is altered by psychological forces.

The important conclusion drawn from the gestalt studies is that there exists a genetic factor in visual perception. The child slowly develops the ability to perceive configurations with some degree of accuracy. The genetic factor is inherent, for example, in the phenomenon of anistropy. Stern[11] found that children, unlike adults, responded to the same configuration irrespective of its position in the visual field. Appplied to the symbols d and p, the configurations of these letters are discrete entities for adults but not for young children. Davidson,[12] Smith,[13] Teegarden[14] and Fildes,[15] working with kindergarten and first-grade children, reported that the tendency to rotate geometric forms and symbols is so common that it is regarded as a natural phenomenon in this age group. This would confirm the impressions of Stern[11] and of Koffka[16] that in the child visual perception is frequently independent of spatial orientation.

Rotation and motion also occur in eidetic images. Rössler[17] found that six-year-old children show the maximum disposition for eidetic imagery, while Petty,[18] who applied this technique to reading readiness, observed that eidetic ability is higher in those who become successful readers. Some children reproduce static images while others endow them with motion. One might anticipate configurational rotation in the latter group.

Psychological.—It is generally accepted that no factor shows so high a correlation to reading readiness and reading proficiency as does mental age. Few mental defectives with an IQ below 50 learn to read,[19] and although higher grade defectives are more successful, special teaching methods and individual training are often necessary. The child with a MA below 6 is not expected

to grasp the fundamental mechanics of reading. Some educators,[20] impressed with the developmental factors which militate against the novitiate's success, have advised that the reading program be postponed in all children for a half year or more rather than risk failure and its unfortunate effects. Reversal tendencies have also been attributed to inferior intelligence. Gordon[21] reported that mirror-writing is most commonly associated with mental deficiency; and in the early literature, sinistrodextrad inversion was often regarded as a sign of degeneracy.

Pedagogical.—Many authorities set the highest value on the use of proper techniques in the reading program and believe that reversals indicate flaws in educational procedure. Gates and Bennett[9] explain that prior to encountering the printed symbol, the child is accustomed to study an object from any angle and come to a meaningful conclusion, while in reading, unless he is taught to proceed in the one accepted direction, reversals may result. They, therefore, emphasize the need to demonstrate left to right progression, the use of manual (finger pointing) guides, and of supplementary devices such as the moving picture, early in the teaching program to foster proper reading habits. Wilson and Flemming[22] support this thesis.

There is little doubt that experience and training are significantly related to the reversal tendency. Hildreth[23] states, and with reasonable justification, that reversals are observed more frequently where the incorrect reading makes sense, i.e., 'on' read for 'no,' but not 'ti' for 'it.' Of interest also is her finding that both seven- and eight-year-old pupils in a private school where reading is deferred in the primary grades made more reversals than did public school children of the same age who were introduced to the subject in the first grade. This occurred despite the fact that the average IQ of the former group was considerably higher. Clearly, experience and training overshadowed intelligence. Similarly, other investigators[24] have shown that Chinese students read Chinese symbols with greater proficiency when the symbols are arranged vertically, whereas their best performance with English letters and Arabic numerals was observed when these were presented in horizontal sequence. These results can be explained almost entirely in terms of the training and habits of the subjects.

PLAN AND DEVELOPMENT OF THE PAPER

Interest in reversals was stimulated by studies made on the children's ward at Bellevue Psychiatric Hospital. In the course of a statistical analysis of educational disability in the ward population it was discovered that up to eighty per cent of the boys sent for observation showed severe reading retardation, and in a large percentage this retardation was of an extreme degree. Dr. Bender, in charge of the children's service, has long been interested in visual-motor performance as a diagnostic instrument and, therefore, most of these children were routinely tested for gestalt function. The crucial observation was made that severely retarded readers rotated horizontally oriented gestalt figures to the vertical position when copying them.

It is the nature of this report that its development shows the stratification of observation, hypothesis, creation of a test, gathering results, further observations, and again building upon them. The tests described below do not represent a battery given to test a single hypothesis. They were, instead, successively devised as the results of earlier ones showed clear trends. When the strong tendency to 'verticalize' gestalt figures was noted in retarded readers at Bellevue Hospital, normal controls were sought. To determine the incidence of vertical rotation, its relationship to age and past experience, it was necessary to carry the experiment to a large group of children in a normal or average setting. The public school where children are distributed more or less according to age and achievement seemed a natural choice. All other experiments were conducted in the public school.

Gestalt performances of five hundred eighty-six school children were obtained and rotational tendencies in the different age levels were classified. It was possible from these results to see the genetic factor in configurational rotation as clearly as Bender[10] had demonstrated the development trend in total gestalt performance. Just as whirling or circular movement, dissociation of fragments, completion and other primitive gestalt tendencies slowly disappear (or are inhibited) as the normal child advances in age, such is the fate of the rotation tendency also.

The next step was to investigate the possibility of the existence of vestiges of the primitive rotational tendency in the same fashion that other characteristics of infantile perceptual performance have been demonstrated—i.e., through a modified techistoscopic experiment. This was done by flashing the gestalt figures for five seconds. The results disclosed the existence of a latent tendency for vertical rotation even at those age levels where copying the stimuli without time limit did not reveal it.

Having established the preference for vertical orientation of horizontal forms, it was then decided to test free choice of direction. A simple test was given in which children were requested to draw straight lines. The results here too supported the previous findings in that the majority of children produced vertically directed lines. Further proof of the vertical trend was sought in another experiment in which children were asked to draw a pencil. Predominantly vertical choice was again obtained, but the results from this test were not regarded as conclusive.

Impressed by current psychological theories of the body image and its significance in perceptual experience, particularly as a projection phenomenon, it was felt that upright body posture may contribute to 'verticalization.' Completion tests were, therefore, given in which the stimuli were simple figures such as a circle, a square, or a modified circle. Preoccupation with the human erect form was clearly brought out in these experiments.

The relationship of vertical rotation of horizontal forms to reading reversals had been suggested by their coincidence in the cases of severe reading disability at Bellevue Hospital. There remained the task of elaborating this relationship in the normal school children. Chang,[25] who has made an inquiry into the relative merits of vertical versus horizontal alignment of print has the following to say about reading: "Reading is not a matter of perceiving isolated and sporadic characters. Whatever the language the characters are arranged in an orderly sequence, with a definite direction. The eye follows this sequence as a line, horizontal or vertical." Several experiments were set up to elucidate the problem by equating the printed word and line with simple line forms. At first the children were asked to copy solid and broken horizontal lines. Although some tendency for 'verticalization' was observed, the results were not definitive.

Since reading calls for a discipline of left to right movement, it was felt that the test stimulus must approximate the accentuation of direction called for in reading. This was accomplished by fixing directional markers such as an arrowhead or terminal circle to the horizontal lines. When the modified horizontal lines were presented, vertical rotation became a striking feature. The results also permitted an evaluation of the genetic factor in 'verticalization' on a simpler scale, and confirmed the findings with gestalt rotations.

Finally, to complete the circle, the 'verticalization' tendency was sought and isolated in a selected group of public school children known to be retarded in reading. This group of nineteen children in the third grade of at least average intelligence, many clearly superior, were given the tests which only now formed a battery. The results confirmed those originally obtained in the severe reading disability cases studied at Bellevue Hospital.

EXPERIMENTAL MATERIAL, METHODS AND RESULTS

I) *Children's Ward, Bellevue Psychiatric Hospital.*—Initial studies were made on the Children's Observation Ward at Bellevue Psychiatric Hospital. As is the case in reports from guidance clinics and institutions, the incidence of reading disability is very high in our group. Furthermore, the predominance of this handicap in boys, a fact also widely noted, is a striking feature. For the purpose of this study, the material is limited to the findings in boys.

Of the total number of male admissions for the period January to July, 1943, amounting to two hundred boys ranging from infancy to twelve years of age, one hundred six or fifty-three per cent fulfilled the criteria of adequate CA (above 7), of IQ (above 80), and of educational experience to warrant further inquiry into reading achievement. In this group of one hundred six boys, eighty-four or 79.3 per cent were retarded in reading; the remaining twenty-two or 20.7 per cent read up to their anticipated level or were accelerated. Of the eighty-four retarded readers, twenty-five or 23.6 per cent of the one hundred six included in the study were complete non-readers, while twenty-six or 24.5 per cent were retarded from fifty per cent to eighty-five per cent of their expected reading level. Most of

these children with severe reading disability—many could not even correctly identify the letters of the alphabet—showed reversals of all types.

Personality studies of these children are not included in this report. It may be said, however, that most of them were not referred because of scholastic failure. Personality disorders, conduct disturbances, and other maladjustments brought them to the attention of the schools, social agencies, and the courts. Many were not known as 'reading disabilities' and several were regarded as mentally-retarded prior to coming to the Hospital for observation. Physical and neurological examinations were within normal limits, and by gross tests and finer tests by specialists when indicated, none suffered from defects in the visual and auditory spheres.

1. Gestalt tests—copied without time limit
Figures: Bender's[10]

As a routine procedure in the examination, each child was asked to copy Bender's gestalt figures. Complete records were available in twenty-one of the twenty-five non-readers and in twenty-five of the twenty-six boys retarded in reading from fifty per cent to eighty-five per cent of the expected level.

Results: In the group of twenty-one non-readers, sixteen or seventy-six per cent rotated one or more of the horizontal figures to the vertical position as is demonstrated below. In the other group of twenty-five showing reading retardation of from fifty per cent to eighty-five, fifteen or sixty per cent showed the same tendency to 'verticalize' the gestalt forms.

II) *Public School.**—In order to gather controls and further elaborate rotational tendencies, the experimental work was continued at one of the public schools of New York City. The school draws its pupils from a mixed population. Approximately five per cent of the children are colored and there is a fair distribution of those of Irish, Italian and Jewish stock, with the majority in the latter category. The social economic status of the neighborhood is a marginal one. The school is considered

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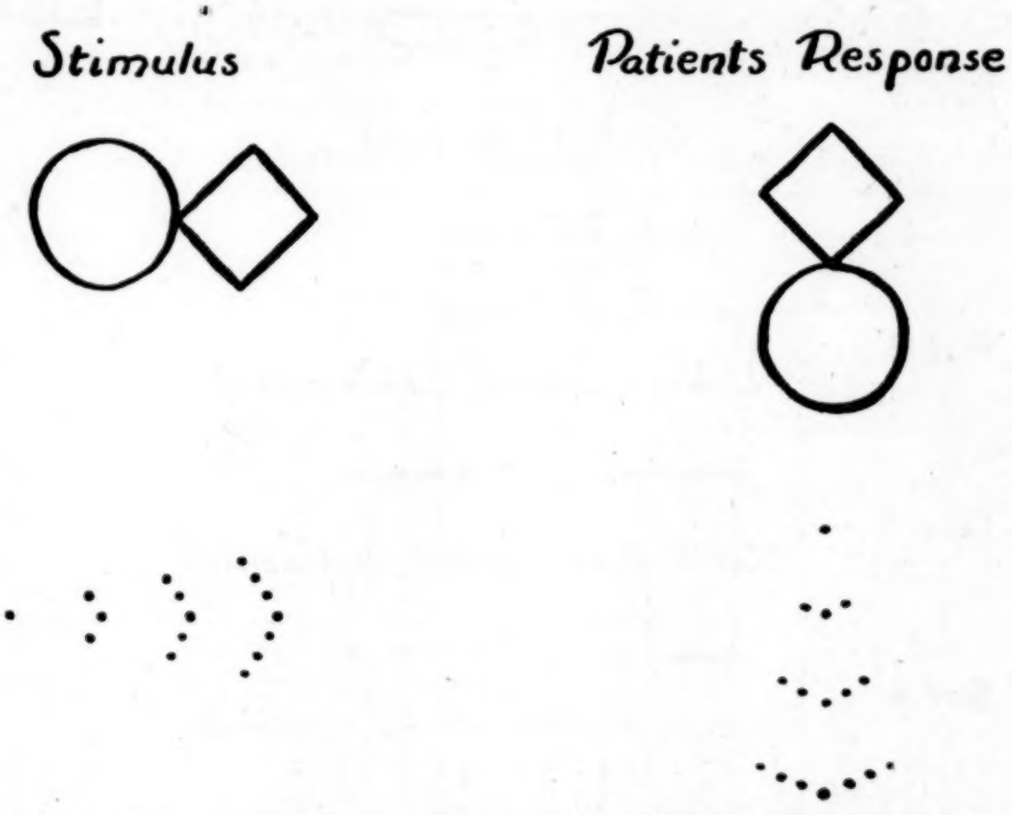
* I am indebted to Dr. M. Lazar of the Bureau of Reference, Research and Statistics of the New York City Board of Education for making the school studies possible.

an average one for the borough of Brooklyn with respect to the intelligence and scholastic achievement of its student body.

Five hundred eighty-six pupils in twenty-six classes distributed from kindergarten through the end of the third grade were tested. The stimulus figures presented to the children to be

Figure 1



copied were centered on large sheets of paper, seventeen by twenty-two inches in size, directly proportional to the eight and a half by eleven inches sheets used by the subjects. For the most part, the forms were presented to whole classes consisting of from seventeen to thirty pupils except in the case of the very young children. Those in the kindergarten classes were tested individually, and here the stimuli were centered on sheets of the same size as those used by the children. All of the first-graders and small groups from each of the higher grades were tested in units of four to six pupils in order to compare the results with those obtained from class studies. The position of the paper on each child's desk was carefully checked before each figure was

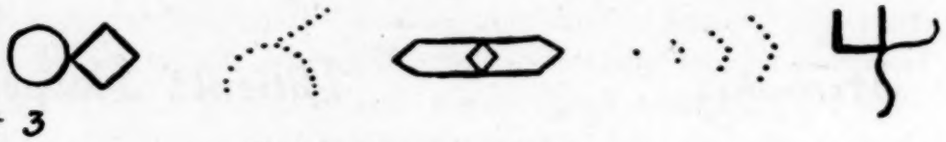
Figure 2

Section II - Public School Children

Test Stimuli

Parts 1 and 2

Gestalt - horizontal



Part 3

Gestalt - vertical

Part 4

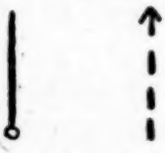
Lines - Simple, horizontal

Part 5

Lines - Accentuated, horizontal

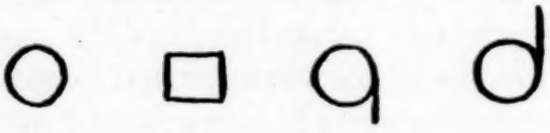
Part 6

Lines - Accentuated, vertical



Part 8

Completion experiment



presented. Where a time limit was to be imposed, this was announced. The following experiments were conducted during the period October, 1943, to June, 1944.

1. Gestalt test—copied without time limit

Figures: Five of The Bender gestalt Figures. (Fig. 2, Parts 1 and 2.)

The gestalt figures were presented to five hundred eighty-six children ranging from five to nine years of age and distributed from the kindergarten through the end of the third grade. All types of rotation were recorded.

Results: The findings are listed in Table 1.

TABLE 1.—GESTALT ROTATION

Class	Age	Number of Children			Figures Copied without Time Limit				Figures exposed for only 5 seconds			
					Per Cent Showing Rotations			Per Cent of Rotations Vertical	Per Cent Showing Rotations			Per Cent of Rotations Vertical
		Total	Boys	Girls	Total	Boys	Girls		Total	Boys	Girls	
Kindergarten	5+	30	12	18	63	50	72	82				
Beginning 1A	6	66	32	34	52	47	56	73				
End 1A	6½	102	49	53	21	20	21	79				
End 1B	7	62	34	28	24	21	28	100				
End 2A	7½	109	58	51	20	19	22	86	35	38	31	76
End 2B	8	70	37	33	6	5	7	100	13	16	9	60
End 3A	8½	98	52	46	6	8	4	83	23	21	26	71
End 3B	9	49	25	24	10	16	4	100	25	20	30	86

Rotation of gestalt forms is a very common feature in the ninety-six pre-school and beginning school children. Over fifty per cent of these pupils rotate the horizontal figures and about eighty per cent of the rotations are from the horizontal to the vertical position. As the child progresses in the school program, the rotational tendency becomes less pronounced. A significant drop in rotations is observed in the two hundred seventy-three children ranging from six and one-half to seven and one-half years of age. It is present in about twenty per cent of these children, and again the majority are vertical rotations. Of the two hundred seventeen children from seven and one-half

to nine years of age, only about seven per cent rotate the figures, and in almost all instances the direction is to the vertical position. Gestalt rotations occurred with about equal frequency in both sexes, with a slightly greater tendency in girls under eight and in boys after this age.

2. Gestalt test—copied after stimuli were exposed for five seconds
Figures: Same as in Gestalt test 1

Tests in which gestalt figures were copied after a five seconds' exposure of the stimuli were administered to three hundred twenty-six children ranging from seven and one-half to nine years of age, those completing the first half of the second grade through the last half of the third grade. When both this test and the previous one (Gestalt 1) were given to the same children, the five seconds' exposure test was administered first. The younger children were omitted from this experiment because of the difficulty of the test situation.

Results: The findings are listed in Table 1.

When the time exposure is reduced, rotations occur more frequently. Thirty-five per cent of the seven and one-half year old children show rotational distortions on this test as compared with twenty per cent in Gestalt test 1. Similarly, in the other age groups rotations are two to four times as common as in the former test where no time limit was imposed. Moreover, the trend towards reduction of the reversal tendency as children advance in age is again observed, although it is less clearly defined than was seen in Gestalt test 1. Vertical rotations predominate; from sixty per cent to eighty-six per cent of all the types are of this variety. The latent tendency to 'verticalization' demonstrates itself in this experiment. The reappearance of this tendency would coincide with the concept of regression in function once optimum conditions are removed. In another sense it implies that vertical rotation is a persistent feature of visual-motor performance which is simply inhibited but not overcome as the normal individual advances in age.

3. Gestalt tests—two figures presented in the vertical position to be copied without time limit. (Fig. 2, Part 3.)

In this test two of the gestalt figures which were most frequently rotated were now presented in the vertical position.

The purpose of the test was to ascertain whether the tendency to rotate figures was specifically related to the form of the stimulus or was a general characteristic of visual-motor performance. The test was given to twenty-three children beginning the first grade, CA 6, two weeks after Gestalt test 1 had been completed.

Results: All of the twenty-three children reproduced these figures correctly with respect to direction, although other distortions such as dissociation and closure were present. It will be recalled that in the Gestalt test 1, over fifty per cent of the children in this age group 'verticalized' horizontal figures. The absence of rotation when the stimuli are vertically oriented reinforces the impression that horizontal configurations are more likely to initiate figure ground changes in young children.

4. Line tests—simple horizontal lines to be copied without time limit. (Fig. 2, Part 4.)

In this test, the stimuli were further simplified to determine the relationship of horizontal configurations to the rotational tendency. Thirty-nine beginning first-graders, tested in small groups of three or four, were asked to copy solid and broken horizontal lines. The stimuli were presented individually and were copied on separate sheets of paper.

Results: Only seven, or eighteen per cent, of the thirty-nine children 'verticalized' one or both figures. This suggested that other factors besides horizontality may be responsible for the more frequent occurrence of rotation noted in the gestalt experiments.

5. Line tests—horizontal lines with direction accentuated by adding markers—no time limit. (Fig. 2, Part 5.)

The modified horizontal lines were presented to three hundred fifty-two children ranging from six to nine years of age and distributed through the first three grades. The younger children were tested in small groups while those in the higher grades were tested by classes of seventeen to thirty pupils. Separate sheets were used for each line form to be reproduced.

Results: The findings are listed in Table 2. Fifty-one per cent of the six-year-old children rotated the accentuated horizontal lines to the vertical position. Of the seventy-three children, CA6½, twenty-two per cent 'verticalized' one or both figures.

These percentages are in agreement with the results on vertical rotation of horizontal gestalt figures. Beginning with seven-year-old children, the percentage of rotations drops more precipitously than did those in the Gestalt test 1, and practically disappears at about seven and one-half years of age. The genetic factor in visual-motor performance is even more clearly demonstrated in this experiment.

TABLE 2.—LINE ROTATION

Class	Age	Horizontal			Vertical		
		Accentuated lines as in Fig. 2, Part 5			Accentuated lines as in Fig. 2, Part 6		
		Total No. Tested	Results		Total No. Tested	Results	
			%V	%H		%V	%H
Beginning 1A.....	6	65	51	49	23	96	4
End 1A.....	6½	73	22	78	55	98	2
End 1B.....	7	38	16	84			
End 2A.....	7½	83	6	94			
End 2B.....	8	50	2	98			
End 3B.....	9	49	0	100			

V = one or both figures vertical.
H = both figures horizontal.

6. Line tests—accentuated lines presented in the vertical position—no time limit. (Fig. 2, Part 6.)

After an interval of several weeks, seventy-eight children, twenty-three entering and fifty-five completing the first half of the first grade, were retested. This time the modified lines were flashed in the vertical position. As in the case of the Gestalt test 3, this experiment was designed to control the influence of axial orientation on rotation.

Results: The findings are listed in Table 2. Only two of the seventy-eight children or 2.5 per cent rotated one or both of the

vertical stimuli to the horizontal, while the others preserved the vertical direction of both. Again one must conclude that up to the age of seven, children are prone to 'verticalize' horizontally directed figures, while vertical figures are reproduced with minimal directional distortion.

7. Choice of direction

(a) Children were instructed to draw three straight lines

To determine the spontaneous choice of direction, several small groups of six year old children, comprising sixty-two in all, were asked, without giving further instructions, to draw three straight lines.

Results: Forty-three or sixty-nine per cent of the children drew vertical lines. The results were not affected by the position of sheet (longer vertical or horizontal axis) on which the children drew. Thus given choice, verticals were drawn more than twice as often as were horizontal lines.

(b) Children were asked to draw a picture of a pencil

In this experiment another attempt at determining choice of direction was made. A total of sixty-nine children, CA 6, were asked to draw a picture of a pencil.

Results: Fifty or eighty-three per cent drew vertical figures and confirms the results obtained in part (a) of this experiment. However, since it is customary to use the pencil in the upright position, the findings in part (b) are not as decisive.

8. Completion experiment. (Fig. 2, Part 8.)

Kindergarten, six and six and one-half year old children participated in a completion experiment. Some were presented with sheets of paper in the center of which a circle had previously been drawn. The instructions were to complete the drawing in any way they chose. The experiment was modified in several ways; others were given either a square, or a circle and adjacent line corresponding to the figure '9' or the letter 'd' instead of a circle.

Results: The results do not lend themselves to statistical analysis. However, the most striking feature of these productions is that the majority of children used the circle as the nucleus for the drawing of a face or completed the figure of a man or woman. The same was true, although to a lesser degree, when

the square or circle and line stimuli were presented. In several instances where the stimulus resembled the small case letter 'd,' the child simply turned the sheet so that the circular portion of the figure was uppermost and proceeded to complete a human figure.

9. Symbol reversals in the public school

It was possible to estimate roughly the tendency to reverse symbols in the public school children. Four hundred ninety children ranging from six and one-half to nine years of age are included in this experiment. They were asked to write letters or words and arithmetical figures which were given to them verbally. In the six-and-a-half and seven-year-old groups, letters which are commonly reversed (b, d, p, q, s, u) as well as single numerals were given. The older children were asked to write such words as 'dog,' 'saw,' 'boy,' in addition to more complex numbers.

TABLE 3.—SYMBOL REVERSALS

Class	Age	Number of Children			Per Cent Showing Reversals of Symbols		
		Total	Boys	Girls	Total	Boys	Girls
End 1A.....	6½	102	49	53	51	55	47
End 1B.....	7	62	34	28	45	50	36
End 2A.....	7½	109	58	51	27	35	18
End 2B.....	8	70	37	33	29	35	21
End 3A.....	8½	98	52	46	5	6	4
End 3B.....	9	49	25	24	0	0	0

Results: The findings are listed in Table 3. Symbol reversals (a child showing even one reversal was classified as positive) were plentiful in the public school children. At the end of the first half year of schooling, about fifty per cent of the pupils made reversals, with only a slight discrepancy between the sexes. At the end of the first year of schooling fifty per cent of the boys but only thirty-six per cent of the girls demonstrated this

tendency. After two years, CA 8, reversals were less common in both sexes, but occurred almost twice as often in boys. The results are in agreement with reports in the literature of the universal tendency to reverse symbols in children in the primary grades. The exaggeration of this tendency in boys is also in harmony with the fact that reading retardation is found more frequently among them.

10. Rotational tendency in retarded readers in the public school

An intensive medical, psychological, and psychiatric study was made of nineteen children in the public school who were retarded in reading. In this group, there were ten children in the upper half and nine in the lower half of the third grade, and they represented the most severely retarded readers of the two hundred four children in both classes. Several other children with educational disability were eliminated from the survey because they did not fulfill the following criteria: adequate intelligence, absence of physical or optical defect, good attendance record, and no school changes. Stanford-Binet (M) scores of the nineteen pupils* ranged between 93 and 129; many of them were of superior intelligence. Individual reading test scores showed retardation in reading of one-half year or more; fourteen were retarded more than fifty per cent of the anticipated reading level (CA and not MA used as the expected standard). Symbol reversals were noted in seventeen of the nineteen children. Especially interesting is the fact that of the nineteen children, only one was a girl and she showed minimal reading retardation.

In addition to other examinations, the gestalt and line tests were administered to these children.

Results: Only one child 'verticalized' the horizontal lines. But, ten of the nineteen, or fifty-three per cent when copying the gestalt forms without time limit, rotated one or more to the vertical position. Rotation of the accentuated horizontal lines disappears early, by the seventh year. Consequently, little evidence of the rotational tendency appears in these eight- and eight-and-a-half-year-old children. But normal children in this

* I am grateful to Miss M. Weber, research psychologist in the New York City Bureau of Reference, Research and Statistics for making these psychometric scores available to me and for her coöperation and assistance in many other respects.

age group (Table 1) 'verticalize' gestalt figures in only six per cent of the cases. The findings in the nineteen children in the public school group coincide with the results obtained in the severely retarded readers at Bellevue Psychiatric Hospital.

'VERTICALIZATION'

The experimental findings indicate that the phenomenon of rotation in visual perception may be studied from a genetic standpoint; that there is a greater tendency to rotate configurations from the horizontal to the vertical than *vice versa;* and that when horizontality is intensified by directional markers, the tendency to 'verticalization' is increased. What is responsible for 'verticalization'?

Physiological.—Muscle mechanics of the arm favor movements in the vertical direction. Mira,[26] who has devised a myokinetic test for psychodiagnosis in which lines are drawn in different axial planes, found that the performances of children were singularly unreliable. In this test, subjects are first shown the lines, make a few practice strokes to copy them, and are then blindfolded and requested to continue making the same lines. Children fail when deprived of visual control, he believes, because of their inability to compensate "for the instinctive tendency to move the hand, the pencil, and the elbow in the same oblique axis corresponding to the plane of semiflexion in which the parts are placed in relation to the arm." Another significant observation that he makes and one which can be readily confirmed, is in connection with the "juvenile tendency to twist the head in writing and to twist the paper analagously so as to place it in a position perpendicular to this axis." Our experimental findings are in agreement with Mira's observations.

When children are tested individually it is possible to observe closely their many attempts at arrivng at a vertical configuration. In copying horizontal lines or other more complex forms the child often cocks his head towards one shoulder. The visual sweep is now in the direction of the length of the figure. Sometimes, annoyed at the peculiar posture he must assume properly to visualize a horizontal figure, the child will take the stimulus sheet from the examiner and arrange it so that the figure now lies in the vertical axis. If this is prevented, another maneuver he may use is to twist the sheet on which he is drawing, copy the

figure vertically and then return the sheet to its original lengthwise position. Still another stratagem is to shift the arm so that it is perpendicular to the sheet, move the arm vertically and yet draw a horizontal line. In some instances, the child becomes lost in the process of shifting his head, his arm, his own paper, or the stimulus sheet, and if he copies several figures on the same page the final product is a confused maze from which no dominant axis can be discerned. But, even if the end result appears accurately oriented, it is impossible to draw conclusions as to directional tendencies if one has not had the opportunity to watch the child's performance. Were the individual operations observed, the tendency to 'verticalize' would be obvious.

Children with organic brain disease are handicapped in spatial orientation as well as in visual motor performance. Rotational tendencies are common. In these children vertical rotation of horizontal figures has been frequently observed.

C.D., a nine-year-old white girl of Italian extraction, one of twins, had kept pace with her twin sister and progressed normally in her development and at school until at seven and one-half years of age she was stricken with encephalitis in the course of an attack of measles. Convulsions complicated the illness and, following one seizure, she became totally aphasic. She was observed on the Children's Ward at Bellevue Psychiatric Hospital and in follow-up visits for a period of nine months, during which time she showed progressive improvement in the language field. Visual-motor tests such as Bender's gestalt figures, Goldstein and Scheerer[27] stick test modified for paper and pencil, and various others improvised along these lines were given at frequent intervals. At first, unable even to grasp instructions, she engaged in meaningless perseverative scribbling. She slowly became amenable to suggestions and enjoyed the test procedures except that her attention span was fleeting and she was easily fatigued. Given simple horizontal lines, she would rotate them vertically and feel that she had made adequate copies. After a few months, although the tendency to 'verticalize' persisted, she was now aware of the difference between her production and the stimulus and would show considerable irritation over her inability properly to execute the task. Even at the close of our period of observation, complex horizontal figures would still be rotated vertically although simpler ones were not.

Psychophysical.—Aside from such influences as proximity, similarity, and the tendency to closure, all of which strengthen configurations, Gestalt psychologists hold as essential the Law of Prägnanz, which states that all configurations tend to become as good and as stable as possible. When, therefore, the horizontal figure, such as the broken line (experiment 4) is directionally intensified through the addition of an arrowhead (experiment 5) and this figure is vertically rotated when copied by a child, the inference is that this rotation occurs because the figure becomes a 'gute' Gestalt and is more stable in the vertical position. The 90 degree rotation, instead of a shift to lesser or greater degree, occurs because the perceptual framework tends towards neutrality, i.e., towards the horizontal or vertical spatial coördinates irrespective of the retinal images. Vernon[28] cites experiments in perception in which the external object is tilted and where the response of the subject is to restore vertical or horizontal orientation. Hanfmann[29] reported the same tendency in children to maintain a perpendicular framework. Since the vertical coördinate is, in man, largely dependent on the upright body posture, tilting the head, commonly observed in children who are sighting, may produce a 90 degree dislocation of the frame of reference.

When direction is intensified, a temporal element is added to spatial considerations and, if both qualities are integrated, there arises the phenomenon of apparent movement. This has been termed the phi-phenomenon[30] by Wertheimer, the pioneer of the Gestalt school. Koffka[16] found that children can see the phi-phenomenon more clearly than adults. Of interest is the relationship between apparent movement and what Schilder[31] refers to as 'the perpendicular streaming phenomenon.' He noted that when parallel horizontal lines are exposed to a subject, movement begins to take place. The movement is always perpendicular to the direction of the lines. If the subject then looks at a white wall, the after-image is of the same order, perpendicular movements going upwards or downwards. Schilder comes to the following conclusions: "Forms would appear to be dominated by movements which form the perceptual material . . . Lines have an inner coherence in one direction to which the inner retinal movement becomes bound perpendicularly."

To both these principles of Prägnanz and apparent movement, not only do the external physical stimuli contribute, but internal

forces of attitude, expectation, and past experience are of the utmost importance. These internal forces may be best considered with the next group of psychological factors.

Psychological.—The child, helpless at birth, is completely dependent for his care and affection upon external figures, upright figures. For a long time pictures of men and a few animals take preference in the objects he depicts, and the same preference is noted in the drawings of primitive people. It is obvious from the crude productions of children that their drawings do not correspond to external reality but to internalized schemata.[32] Not only are these schemata based on perceptual experiences, but, as Schilder[33] has stated, each individual develops within himself the concept of his own body image.

Opposed to empirical formulations which regard visual experience as pure sensation unaffected by higher mental processes, Jaensch[17] believes that objective visualization is an ideal towards which each individual advances, but rarely achieves. Internalized schemata are projected by children and the shape of the thing created or perceived may be dictated by subjective factors divorced from external reality. In this connection, the important contribution of the concept of the body image to visual experience cannot be overemphasized. C.D., the aphasic child described above, would, for example, on being shown the arithmetical figure '9,' often complete the picture spontaneously by adding facial features to the upper circular portion and a stroke for another supporting limb. The completion experiment with normal school children showed the same tendency to project the body image. Piaget[34] found that in children through the seventh and eighth years, thought and language are dominated by egocentric intuitive attitudes which interfere with 'perceptual intelligence.' Thought and language of the child, he says, are artistic and "still tied to imagery, to organic activity and even to organic movements." As a consequence phantasy may dictate that external events are real when nonexistent or distort others that do exist.

'VERTICALIZATION' AND READING REVERSALS

What is the relationship of 'verticalization' to reading reversals? Learning to read calls for the establishment of a specific directional discipline—horizontal movement from left to right. One would expect, and the anticipation is realized, that in the young child

this directional requirement would clash with the tendency to rotate horizontally oriented configurations to the vertical position. It should be recalled that in one of the earliest attempts at written language—Chinese—the symbols are arranged vertically. Equally significant is the fact that many children of adequate intelligence who show severe reading retardation achieve, in striking contrast, good success in arithmetic, where the symbols and various operations performed are vertically directed. It is difficult to conceive of separate brain centers for reading and arithmetical symbols. Directional tendencies must play a rôle in the difference in proficiency observed in these two subjects.

Because of the horizontal typographical layout, most investigators have emphasized reversal errors of the type in which the symbols rotate around the vertical axis, i.e., 'b' equals 'd,' and 'p' equals 'q.' Such distortions have been referred to as mirror-writing, sinistrodextrad inversion, and strephosymbolia.[35] In an analysis of reversals by Wechsler and Pignatelli,[36] it was suggested that the factor of tridimensional vision sets up the possibility of rotation in any one or a combination of the three spatial planes. It would be otherwise difficult to explain the substitution 'd' for 'p,' 'N' for 'Z,' or 'y' for 'h,' on the basis of single axis rotation. 'Verticalization' gives the clue to multiplaned axial rotation of symbols and to substitutions which cannot be explained as mirror image distortions or single plane shifts. Examples follow:

Symbol or word	'Verticalization'	Reversal
u	u	n
saw	saw	mas
dog	dog	bop or bog

'VERTICALIZATION' IN THE READING PROGRAM

The phenomenon of 'verticalization' has both diagnostic and pedagogical implications. There have been many attempts in recent years to predict the individual child's success in the reading program through the use of various reading readiness tests. The importance of incorporating the concept of 'verticalization'

into such tests seems clear. Since simple accentuated lines are 'verticalized' up to age seven by many children, while complex gestalten are vertically rotated even through the eighth year, the advisability of postponing the reading program for a half to one year after entrance into the first grade is also suggested.

Teachers of reading in the primary grades should be acquainted with the strong 'verticalization' tendency which characterizes the six- and seven-year-old child. They should be alert to detect early in the program axis deviations related to head tilting, perpendicular arm movements and rotation of the paper on which symbols are transcribed. Corrective exercises should be designed to emphasize horizontal and vertical guides of the spatial framework. For the beginner prophylaxis is necessary, while for those in whom reversal tendencies are chronically established, retraining with emphasis on horizontal movement is imperative.

Equally significant is the fact that 'verticalization' is a developmental phenomenon and that fixation in development or regression may result from psychopathological factors. Just as any symptom such as enuresis calls for an investigation of all spheres —intellectual, organic, and psychological—so similarly the persistence of 'verticalization' should make one inquire into the possibility of mental deficiency, organic brain disease, or reactive features in the individual case. Inadequate endowment and nervous system pathology may be more easily and impersonally screened than neurotic elements which demand more intimate inquiry for their elucidation. The difficulties inherent in such an inquiry should, however, not lead to minimizing its importance in the reading program if such a program goes beyond curriculum and seeks the reasons for failure to profit from it.

CONCLUSIONS

The tendency to rotate horizontally directed configurations to the vertical position is found in the normal child of pre-school and beginning-school age. It is a developmental phenomenon which is gradually corrected as the child matures but does not disappear until he is seven or eight years of age.

Physiological, psychophysical and psychological forces contribute to this tendency.

When configurational horizontality is accentuated, 'verticalization' becomes more compelling for the child.

Symbol and word reversals are related to the 'verticalization,' tendency since accentuation of horizontality is implied in the discipline of left-to-right movement which is impressed on the beginning reader.

The 'verticalization' phenomenon may explain multiplaned axial rotation of symbols which are not mirror images or single plane rotations.

The persistence of the 'verticalization' tendency should be detected early in the reading program through the use of visual-motor tests. It is also well to look for overt manifestations of the same tendency, such as perpendicular arm movements in writing, head tilting in sighting and writing, and rotation of the paper on which symbols are transcribed. Exercises designed to correct these tendencies must be instituted as soon as they are discovered and continued as long as they persist.

Although 'verticalization' is a developmental phenomenon, its persistence may be indicative of either mental deficiency or organic brain disease where it is a regressive feature. In the general school population, however, these abnormal conditions are relatively infrequent and, if present, they can be readily ascertained. Much more common are infantile patterns of behavior due to emotional difficulties or environmental handicaps which inhibit the learning process and which betray themselves by primitive visual-motor tendencies such as 'verticalization.'

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INTELLIGENCE AND IMPROVEMENT IN SCHOOL SUBJECTS

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In view of the vast number of studies which have been made of the intercorrelations of achievement scores in a given grade, it is surprising that so few have been devoted to intercorrelations of measured improvements from one grade to the next. One reason for this neglect may be that the ability to improve has often been assumed to be synonymous with intelligence.[1,2,3,4,5] That little support for this view can be found in the gains made by grade-school pupils, over a period of a year or longer, is obvious from the data presented below. Two recently completed studies will be described. The results obtained suggest that prevailing concepts concerning the determining conditions of the gains made by school pupils are still in need of considerable development.

The measures of improvement used in each study were based on objective test-scores yielded by standardized achievement tests in the following six school skills or subject-matters: reading, vocabulary, arithmetic fundamentals, arithmetic problems, English, and spelling. The average published reliability coefficient of these part scores is .86.* The data have been studied particularly for their bearing on two questions: (1) whether the ability to improve is synonymous with intelligence, and (2) since the answer to the first question turns out to be negative, whether there is any general ability to improve, that is, any common factor, intelligence or otherwise, manifested in the gains in the various school subjects.

It should, of course, be kept in mind that the apparent determining condition of gains in school, that is, school attendance for a stated time in a given school class, although a more natural or life-like condition than practice conducted in a laboratory, is, in reality, a complex of variables which are not kept constant for all the pupils. Some variables which readily come to mind are irregularities in attendance at school, interest and liking for the subject, health, study habits, level of aspiration, various

* Metropolitan Achievement Tests, Supervisor's Manual, World Book Co., 1939, p. 72 (Tests 1, 2, 3, 4, 5, and 9, grades IV–VIII incl.).

home influences, and a complex of conditions, not too well understood, determining what is rather vaguely called motivation. In spite of the lack of experimental control of conditions in the school situation, it is interesting to observe that gains in various school subject-matters or skills, at least in the upper grades, show about the same lack of relation with each other and with intelligence as do the gains observed under better controlled laboratory experiments on the effects of practice.[6,7,8,9]

The first study, carried out in the grammar grades of the small town of Litchfield, Illinois, deals with improvements occurring in one calendar year, in the case of pupils of the fourth, fifth, and sixth grades. Since none of the children repeated grades in this school, upon the second testing the fourth-grade children were in the fifth grade, the fifth-grade children in the sixth grade, and the sixth-grade children in the seventh grade. The Metropolitan Achievement Battery was given to all pupils on the same half-day in May of successive years, different forms being used each year.* The Intermediate Partial Examination was given in Grades IV to VI and the Advanced Partial Examination in the seventh grade. Each of the gain scores used consists of the difference between the two scores yielded by the Metropolitan Tests on successive years. The index of intelligence used was an average of scores obtained on two testings by the Otis Quick-Scoring Mental Ability Test, Form Alpha one year, and Form Beta the following year.

TABLE I.—AVERAGE ACHIEVEMENT SCORE INTERCORRELATION

Group	First Testing	Second Testing
5th grade.....	.536	.626
6th grade.....	.656	.641
7th grade.....	.557	.557

Before giving the correlations between improvement scores, it may be well to refer briefly to the correlations† of achievement scores. These correlations were as large as, or perhaps larger than, those usually found. A few were over .80, and most of

* The tests were given the pupils by their teachers. The scores were kindly furnished the writer by O. M. Chute, Superintendent.

† All correlation coefficients given in this paper are coefficients of linear correlation (Pearson coefficients).

them were between .50 and .70. The average of the fifteen intercorrelations between the six achievement scores at each testing are shown in Table I. The mean of all the correlations represented in the table, numbering forty-five, is .60.

In spite of these very considerable correlations between achievement scores, the correlations between the gains occurring in one year were very low indeed. These correlations are given in Table II. Included also are the correlations shown by the separate subject-matter gains with average IQ. Of the forty-

TABLE II.—INTERCORRELATION OF ONE-YEAR GAINS IN ACHIEVEMENT

The abbreviations represent the one-year gains in scores, as follows: R, reading; V, vocabulary; AP, arithmetic problems; AF, arithmetic fundamentals; E, English; S, spelling. CA stands for chronological age and IQ for the average IQ of the first and second testings.

	R	V	AP	AF	E	S	CA
V	.198						
AP	.208	.287				4th to 5th	
AF	.148	.347	.468			Grade	
E	.126	.095	−.028	.071		(N = 94)	
S	.212	.131	.168	.261	.005		
CA	−.267	−.321	−.213	−.250	.061	−.316	
IQ	.422	.341	.508	.432	−.065	.395	−.675
V	.112						
AP	−.119	.229				5th to 6th	
AF	.043	.210	.417			Grade	
E	.115	.035	.052	−.039		(N = 96)	
S	−.032	.192	.005	.224	−.106		
CA	−.202	−.257	−.180	−.140	−.009	−.092	
IQ	−.001	.233	.306	.273	−.127	.264	−.720
V	.183						
AP	.177	−.022				6th to 7th	
AF	.156	.092	.193			Grade	
E	.156	−.024	.050	−.107		(N = 102)	
S	.080	.216	.064	.134	−.112		
CA	−.162	−.073	−.062	−.015	−.165	−.178	
IQ	.169	.124	.076	.012	−.028	.250	−.754

five intercorrelations between gain scores, only three are large enough to be significant by the criterion of three times their standard error. Of these three significant correlations, two were correlations between gain in arithmetic problems and gain in arithmetic fundamentals, one of .468 in the fifth grade and one of .417 in the sixth grade. Nine of the correlations were negative, and the average of the entire forty-five correlations was only .12, a figure which contrasts strongly with the average intercorrelation of .60 obtained between the test scores for any one date and grade. Certainly the low average intercorrelation of .12 between the gains lends no encouragement to the idea that these gains are determined to any important extent by one and the same general ability to improve in mastery of school subjects during one year of study.

The conclusion reached by direct examination of the intercorrelations of the gains was confirmed and extended by means of factor analyses carried out separately with the intercorrelations of each grade, by means of the centroid method, with rotation of axes. The rotation of the factors is admittedly a somewhat arbitrary one and does not pretend to reveal what Thurstone calls primary abilities. The results are shown in Table III.

In the two higher grades, the conclusion that there was no general learning factor at all in the one-year gains is established to a high degree of certainty. In the lowest grade, that is, for the gains made from the fourth to the fifth grade, all gains but one showed positive correlations or 'loadings', varying from .35 to .44, with the same factor. Only the gain in English showed no positive correlation with this factor (the correlation in this case being −.068). The lack of correlation of gains in English with this factor, in the fifth-grade group, is verified by the very low correlations of these gains with those in arithmetic fundamentals and arithmetic problems, .071 and −.028, respectively. Of course, it is possible that some special local conditions accounted for the low correlations shown by the English gains; and the fact that all other gains showed a positive correlation with the common factor, suggests the possibility that in the primary grades all gains in particular achievement tests might, as a rule, show a significant correlation with one general factor. This factor, which in the fifth-grade group was a general factor except for English, correlated .933 with IQ, and could, therefore,

TABLE III.—CORRELATIONS OF GAINS WITH ROTATED ORTHOGONAL FACTORS

h^2, the sum of the squares of the four factor loadings, is the proportion of the total variance of a gain accounted for by the four common factors.

Fifth-grade Group

	I	II	III	IV	h^2
R	.440	−.024	.278	−.029	.2723
V	.347	.374	.213	.084	.3127
AP	.433	.449	−.013	−.034	.3904
AF	.368	.546	.079	.288	.5227
E	−.068	.017	.435	.105	.2052
S	.433	.002	.050	.229	.2424
CA	−.707	−.072	−.001	.205	.5469
IQ	.933	.219	−.107	−.136	.9484

Sixth-grade Group

	I	II	III	IV	h^2
R	.050	−.091	.421	.105	.1990
V	.130	.341	.199	.322	.2765
AP	.165	.540	.076	−.042	.3264
AF	.166	.683	.002	.028	.4949
E	−.107	.009	.321	−.080	.1209
S	.107	.187	−.132	.261	.1319
CA	−.856	.062	.334	.095	.8571
IQ	.800	.259	−.150	.324	.8346

Seventh-grade Group

	I	II	III	IV	h^2
R	.151	.129	.482	.263	.3409
V	.121	.001	.059	.425	.1987
AP	.039	.304	.240	.001	.1515
AF	−.030	.489	.050	.153	.2659
E	.036	−.120	.381	−.099	.1707
S	.255	.177	−.100	.408	.2728
CA	−.936	−.028	.124	−.103	.9099
IQ	.825	.125	.004	.047	.6984

presumably be identified as largely the same thing as intelligence as measured by the Otis Tests.

In the two higher grades, also, there was revealed an intelligence factor, i.e., a factor which correlated highly with IQ. For grades VI and VII, the correlations of this factor with IQ were .800 and .825, respectively. In these grades, however, the correlations between the gain scores and this intelligence factor varied around zero (from .255 to $-.107$), and none of them can be considered statistically significant. For the sixth grade, they averaged .085; and for the seventh, .095. In these two grades, then, the gains may be said to show no general intelligence factor.

Besides the IQ factor, two, and perhaps three, other factors were found. One of these (factor II in Table III) was a factor common to the two arithmetical gains, those in arithmetic fundamentals and in arithmetic problems. These two gains had a considerable loading with this factor in all grades, and in the fifth and sixth grades vocabularly gain also correlated with this factor to a degree possibly significant (.374 in Grade V and .341 in grade VI).

A third factor (factor III in Table III) had to do with gain in verbal performances, particularly reading and English. This factor showed correlation with gains in reading of .278, .421, and .482 in the fifth, sixth, and seventh grades, respectively. With gains in English, it showed correlations of .435, .321 and .381. The variation in the loadings of these verbal tests in the different grades may possibly be attributed to differences in course content and teaching. On the other hand, it may well be supposed that the nature of the factor itself varied somewhat with the correlational matrix from which it was extracted. In no grade, however, does this factor have any marked relation to Otis IQ; and it is, of course, since the extracted factors were uncorrelated, entirely unrelated to the chief factor in Otis IQ, that is, to factor I. In the case of the first two factors, it is quite certain that much the same factor is involved in all grades, the first of these two factors being identifiable by its very high correlations with IQ and the second by the fact that the two sorts of arithmetical gain are always definitely correlated with it. Only in the case of these two factors is it possible to postulate an approximate identity in the case of the different grades. A

fourth factor was extracted, but its significance is slight and it appears very doubtful that it has the same interpretation in the case of the different grades.

Lastly, attention should be called to the fact that even when the four common factors extracted are all taken together, they account for only a part of the total variance in the gain scores. This is shown by the columns headed 'h^2', the proportions listed in which may be interpreted as the sum of the variances produced by the four uncorrelated factors; and, further, if the total variance in any one gain is taken as 1.0, these proportions also represent the proportions of the total variances of the various gains accounted for by the joint effect of the common factors. Now these proportions averaged as follows: fifth-grade group, .324; sixth-grade group, .258; and seventh-grade group, .233. The conclusion is indicated that by far the larger part of the variance in gains is due either to errors of measurement in the gains or to specific factors, that is, factors varying from gain to gain and not common to the gains in any two subject-matters. In all probability both errors of measurement (sometimes called errors of response), and specific factors are important causes of the gain variances. The relative importance of these two causes, however, cannot be specified because of lack of knowledge of the reliability of the gain scores*. It is not possible even to state the reliability of the single scores, since it would be unsafe to assume this reliability to be the same as the published reliabilities (averaging .86). One might guess the average reliability of the single tests to be about .80, and the reliability of the gains to average somewhere between .40 and .50. If the gains have an average reliability of .40, which is certainly a very conservative estimate, it would still follow that specific factors were, roughly and on the average, about half as important (that is, contribute about half as much to the total variance of the gains) as all four of the group factors taken together.

In general, then, results of this study may be summarized as follows:

1) No gain factor was found in the case of any grade which had to do with gain in all six of the subject-matters.

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* The specificity of a gain would be equal to $(r_{11} - h^2)^{1/2}$, in which r_{11} represents the reliability of the gain.

2) Instead, the intercorrelations revealed three group factors: I. A factor which was exceedingly important in determining IQ score and which may be termed intelligence; II, a factor common to arithmetic fundamentals and arithmetic problems; and III, a verbal factor having to do with scores in reading and English. Factor I, the most important in determining Otis IQ, had practically nothing to do with gains in any of the school subjects in either the 6th or 7th grade.

3) For the most part, the gains as measured were unique, that is, due neither to any one of the common factors nor to all of them taken together, but to a combination of errors of measurement and the specific factors. It is probable that gain in each subject depended at least half as much upon its own specific factor as upon all the common factors taken together.

The above conclusions are substantiated by those resulting from an analysis of the gains made by the pupils in one of the grade schools of Providence, Rhode Island. The tests used in the latter case were the Stanford Achievement Tests. The scores furnished* consisted simply of the percentile scores (by class-intervals), based on actual city-wide distributions. These were changed into standard scores on the assumption of a normal distribution. The scores which were correlated, then, are the changes which occurred in the pupil's standard scores, i.e., the standard score of one year minus the standard score of some preceding year. The differences used were for three different periods, namely; those from the seventh to the eighth grade, from the fifth to the seventh grade, and from the fifth to the eighth grade, that is, for periods extending over one, two, and three years, respectively. These differences were calculated for all children who were present in school at the time the tests were given in all three of the grades, that is, the fifth, seventh, and eighth. There were one hundred twenty-two such children. Thus, all three sets of gains, whether for one, two, or three years, are calculated from scores of the same one hundred twenty-two pupils.

The intercorrelations between various school subject-matter gains (or changes) are shown in Table IV. As in the case of the Litchfield pupils, the correlations are very low. For the one-year

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* By the kindness of Richard D. Allen, Assistant Superintendent.

changes, they average .097; for the two-year changes, .182; and for the changes occurring over a period of three years, .108. While most of the forty-five correlations are positive, six (distributed among the three grades) are negative. Only seven of them exceeded three times their standard error. Of these seven, three, one in each group, were between arithmetic fundamentals and arithmetic problems. Only three of the entire set of forty-five correlations exceeded .30. These three were all in the two-year gain group. Of these three correlations, the highest was .420, between arithmetic fundamentals and arithmetic problems.

TABLE IV.—INTERCORRELATIONS OF CHANGES IN STANDARD SCORES IN ACHIEVEMENT IN SCHOOL SUBJECTS

The abbreviations represent changes in score in the various subjects, as follows: R, reading; V, vocabulary; AP, arithmetic problems; AF, arithmetic fundamentals; E, English; S, spelling; and IQ, intelligence quotient, as measured by the Henmon-Nelson tests while pupils were in grade A6.

	R	V	AP	AF	E	S
One-Year Gains (B7 to B8)						
V	.240					
AP	.111	.234				
AF	.069	.143	.256			
E	.061	.110	.002	.107		
S	−.043	.104	.036	−.015	.043	
IQ	−.125	−.120	−.141	.029	−.064	−.092
Two-Year Gains (B5 to B7)						
V	.170					
AP	.259	.364				
AF	.108	.371	.420			
E	.188	.256	.182	.109		
S	.087	.033	.089	−.011	.079	
IQ	.016	.030	.077	.014	−.119	−.002
Three-Year Gains (B5 to B8)						
V	.178					
AP	.140	.217				
AF	−.069	.189	.265			
E	.080	.197	.139	.190		
S	−.004	.063	.021	.004	.080	
IQ	−.151	−.082	−.058	.113	.169	−.077

The low magnitudes of these correlations indicates that any common factor present in the gains must have been relatively unimportant.

The correlations of the gains over the three-year period, that is, from the fifth to the eighth grade, were subjected to a factor analysis. The results are shown in Table V. One factor (II), as before, was clearly one common to the two arithmetical tests. The only other significant factor (I) was one in which reading and vocabulary had loadings of .496 and .481, respectively, and English, one of .310.

TABLE V.—FACTORS (AFTER ROTATION) IN THREE-YEAR GAINS

	I	II	III
R	.496	−.036	−.039
V	.481	.160	−.082
AP	.284	.479	−.060
AF	.001	.563	.023
E	.310	.215	.226
S	−.054	.106	.220

All three of the common factors taken together account for only twenty-three per cent of the total variance. The remaining seventy-seven per cent of the variance must be due to errors of measurement and specific factors.

No significant correlation existed between the gain scores and IQ in the case of any test in any group. These correlations ranged from .169 to −.151, and showed the following averages: one-year gains, −.055; two-year gains, .046; and three-year gains, −.014. Obviously no reasonable correction for attenuation (or errors of measurement) could change these insignificant correlations into significant positive ones.

The general conclusions reached by this study of changes in score in school subjects over a period of from one to three years are identical with the conclusions drawn from the Litchfield data for changes in score over a period of one year:—no general gain factor; lack of significant relation between change in score and IQ in grades beyond the fifth; a common factor in the case of the two arithmetical gain scores; a common factor in gains in reading and other verbal tests; and indications of the importance of the specific factors.

In general, it is obvious that neither the Litchfield nor the Providence data lend any encouragement to the identification of intelligence with learning ability as indicated by gain in school subjects. This statement is made with the qualification that learning ability is measured by the gain in score over some fixed period. If one takes as one's measure of learning ability the pupil's total achievement, that is, the difference of score at any given time from zero, then obviously the correlation between intelligence and ability to learn is identical with the correlation between intelligence and achievement score at a given time. This correlation is a pronounced one, particularly if corrected for attenuation. It is significant, however, that the correlation between intelligence and achievement reaches its maximum rather early in the school grades. This is not what one would expect if gains depended mainly on intelligence. One might then reasonably expect correlation with intelligence to show a marked increase in the higher grades as compared with the lower grades. While, then, the present data do not disprove the allegation that intelligence may be the chief determiner of how much the individual has learned in the past (measured from zero), they strongly indicate that intelligence cannot be postulated generally and without qualification to be the chief determiner of how much the pupil will learn in the future. If the first measurements of intelligence and achievement are made beyond the fifth grade, the indications are that intelligence, far from being the principal factor, is a rather minor factor in accounting for individual differences in improvement in any specified number of additional years. Moreover, in such a case there is no evidence of any other general factor, that is, a general unitary learning ability other than intelligence, possessing an all-pervading importance as a determiner of future gains. Instead, amount of future gain seems (for reasons which the present study does not divulge) to correlate chiefly with quasi-general and specific factors, the former varying from one group of subject-matters to another and the latter from one subject-matter to any different one.

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THE USE OF PREVIOUS RECORD IN ESTIMATING COLLEGE SUCCESS

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We are often told that the ultimate aims of science are prediction and control. Certainly college authorities are interested in predicting, or at least in getting some estimate of, the quality of work of which college students are capable—the quality of work which they are able and likely to do. For this purpose, it is customary to give a college aptitude test to entering freshmen, sometimes repeating a similar test a year or two later. Perhaps one of the chief advantages of using the term 'college aptitude' rather than 'intelligence' is that we can devise measures which show objectively whether students are apt at their studies—grade points, for instance—and then calculate correlations between these measures and scores on aptitude tests, thus demonstrating whether or not scores on these tests do indicate the degree of success which these students will achieve in their studies. If these test scores indicate ahead of time that the student will or will not be apt at his studies, or approximately the extent to which he will be apt, then such tests may rightly be called 'aptitude tests,' whatever may be the ultimate nature or origin of intelligence. It is well known that correlations between scores on aptitude tests and measures of scholastic success usually run between 0.40 and 0.55. This is not high, but it is useful.

Many studies have shown that correlations may be pushed higher, and our predictions of probable future success made more accurate, by giving additional tests or collecting additional information concerning our students. In spite of the low validity of teachers' marks, high-school records have been found to be useful, especially when combined with other evidences of student ability and drive. In connection with low validity of teachers' marks in particular and human judgment in general, the author has shown that when objectivity is used as a criterion of validity, individuals may not agree to a very marked degree among themselves on any given judgment and yet a pooled judgment of one group of individuals may agree to a very high degree with a pooled judgment of another group. Individual objectivity may

be low but group objectivity may be high.[1] Since a high-school graduate usually enters college with sixteen units of credit; since the grade received in each unit is likely to be based upon, perhaps, five examinations in the subject represented by that unit; and since each unit probably represents at least one high-school subject taught by a different instructor in most cases, we have a composite judgment based upon about eighty examinations, evaluated by about sixteen instructors at different times and under different circumstances. The composite judgment can be shown to have considerable merit in indicating, in connection with other measures of aptitude for college work, the probable degree of success which may be expected from college students.

The author has wondered whether or not in our zeal for giving tests we were not often failing to make adequate use of much valuable data already collected in the high school. In the institution in which he works, the freshman's high-school record is summarized by the registrar's office into number of recommended units (A's and B's) and number of non-recommended units which the student earned in high school. It occurred to him that these might be converted into one figure, indicating the percentage of high-school grades which were recommended and this figure used in a multiple-prediction formula including the freshman's aptitude percentile, his reading percentile, his English A percentile on an objective examination given to all college freshmen. The formula then became

$\bar{X}_1$ = Number of grade points which the student might be expected to earn during his first semester in college.
X_2 = Percentage of recommended grades from high school.
X_3 = Aptitude percentile (American Council on Education Psychological Examination for Entering Freshmen).
X_4 = Reading percentile (Iowa).
X_5 = English A percentile (an objective examination).

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Some objections will at once occur to the reader. Percentile scores are not the best scores to use in calculating correlations. Probably not; but they are the scores to which deans and advisers refer in attempting to form some opinion concerning the student's probable scholastic ability. Also, since test forms change from year to year, percentiles seem to represent a better common denominator than crude scores, which do not mean the same thing from form to form or from test to test. A second objection will be that high-school grades do not mean the same from teacher to teacher, subject to subject, or school to school. Admitted. However, it will be seen that in spite of these objections, the high-school record is as good for prediction purposes as the aptitude or reading percentiles. A multiple-prediction formula is, of course, superior to a formula based upon any single set of test scores.

An explanation should probably be offered for predicting grade points rather than 'grade point averages' (grade points earned ÷ units earned). In the judgment of the author, the former is a better measure of student success than the latter. Suppose one student earns all A's on a program of twelve units; his grade point average is 3.00. Suppose another student earns all A's on a program of sixteen units; his grade point average is also 3.00. Any one seeing only the grade point averages might assume that these students are equally good. If, on the other hand, they are compared on the basis of grade points only, the first student is found to have earned thirty-six grade points; the second student, forty-eight. It seems reasonable to suppose that it takes more ability and drive to earn sixteen units of A's than twelve, and the method of using grade points for comparing scholastic abilities shows this difference in ability; the method of grade point averages does not.

In Table I are the correlations which were obtained among the various factors used in estimating the number of grade points which the student would probably earn during his first semester in college.

It will be noted that although none of the correlations are high, one measure seems to be approximately as good as another. The correlation between grade points and the number of recommended units earned in high school is slightly higher than the other

correlations. This does not in any way detract from the value of college aptitude scores. The development of a test which can give in one hour of testing about as good an indication of probable college success as can the composite record established during four years of high school is a definite achievement in the measurement of human capacities. On the other hand, the results of this and other similar studies indicate that it should be good sense to use the high-school record along with other measures of student capacity and drive in order to assure ourselves more adequately that we have measured these qualities as fully and accurately as possible. It is too risky to advise a student on the basis of a single measure such as an aptitude percentile score or an IQ score. Too many things can happen during a single examination partially to invalidate such a score. Several measures should give us greater assurance in our guidance services to the student.

TABLE I.—CORRELATIONS AMONG VARIOUS FACTORS USED IN ESTIMATING THE PROBABLE NUMBER OF GRADE POINTS WHICH STUDENTS WOULD EARN DURING THEIR FIRST SEMESTER IN COLLEGE

	1	2	3	4	5
	Predicted grade points 1st semester	Percentage of recommended units from high school	College aptitude percentiles	Iowa reading percentiles	English A percentiles
1		0.55	0.42	0.44	0.51
2	0.55		0.37	0.45	0.57
3	0.42	0.37		0.71	0.47
4	0.44	0.45	0.71		0.63
5	0.51	0.57	0.47	0.63	

The author was curious to discover how closely he could predict the number of grade points which each freshman would earn during his first semester in college. For this purpose, he devel-

oped, by the usual method, the following multiple-prediction formula:

$$\bar{X}_1 = .15X_2 + .07X_3 + .02X_4 + .08X_5 - 1.01 \pm \sigma_{1.2345} = 7.97$$

The subscripts refer to the factors in Table I. The study was based upon the records of nine hundred three students. The standard deviation of the distribution was 10.20 grade points. The standard error of estimate from the multiple-prediction formula, 7.97, is not flattering, although it does indicate useful possibilities in dividing freshmen into broad categories of excellence and in advising them as to the approximate size and quality of program which they ought to undertake. Later, every possible combination of formulae was developed so that prediction could be based upon any data available. The reader will probably be interested only in the extent to which the standard error of estimate varied with the various combinations of factors used. They are as follows:

$\sigma_{1.2} = 8.52$	$\sigma_{1.3} = 9.26$	$\sigma_{1.4} = 9.16$	$\sigma_{1.5} = 8.79$
$\sigma_{1.23} = 8.18$	$\sigma_{1.24} = 8.25$	$\sigma_{1.25} = 8.15$	$\sigma_{1.34} = 9.03$
$\sigma_{1.35} = 8.52$	$\sigma_{1.45} = 9.09$	$\sigma_{1.234} = 8.12$	$\sigma_{1.2345} = 7.97$

$R_{1(2345)}$ equals 0.62, somewhat higher than the highest zero-order correlation.

Out of curiosity, the author checked the first thirty-three predicted grade points against the actual grade points earned. Eighteen predictions were too high, running from .82 to 15.67 grade points above the predictions, with an average of 6.78. Fifteen predictions were too low, running from .42 to 15.93 grade points below the predictions, with an average of 6.03. The sample was well within the standard error of estimate, 7.97. For a later sample of 1058 cases, the correlation between predicted grade points and actual grade points was 0.57.

Having established the point that the high-school record can very usefully be included in a formula for estimating the student's success during his first semester in college, it was interesting to investigate the effect of inclusion of the first semester's record (as indicated by the number of grade points earned) in a multiple-prediction formula for predicting his success during the second

semester. The English A scores were not available, so the variables used in estimating the second semester's grade points were

$\bar{X}_1$ = Estimated grade points second semester.
X_2 = High-school record (percentage of recommended grades).
X_3 = College aptitude percentile (ACE).
X_4 = Reading percentile (Iowa).
X_5 = Grade points first semester.

In Table II are found the zero-order inter-correlations among these variables.

TABLE II.—CORRELATIONS AMONG VARIOUS FACTORS USED IN ESTIMATING THE PROBABLE NUMBER OF GRADE POINTS WHICH STUDENTS WOULD EARN DURING THEIR SECOND SEMESTER IN COLLEGE

	1	2	3	4	5
	Predicted grade points 2nd semester	Percentage of recommended units from high school	College aptitude percentiles	Iowa reading percentiles	Grade Points 1st semester
1		0.45	0.38	0.39	0.68
2	0.45		0.37	0.45	0.55
3	0.38	0.37		0.71	0.42
4	0.39	0.45	0.71		0.44
5	0.68	0.55	0.42	0.45	

It will be noted that the correlations between estimated grade points and high-school record, aptitude, and reading records were all lower for the second semester's predictions than for the first semester's predictions. With the passage of time, these measures seem to lose some of their value as indicators of probable future success. On the other hand, the correlations between first semester's grade points and second semester's grade points was

0.68, indicating that the previous semester's record is a better indicator of scholastic success during the second semester than any other single factor used. The multiple-prediction formula for the second semester was

$$\bar{X}_1 = .05X_2 + .02X_3 + .03X_4 + .57X_5 + 3.47 \pm \sigma_{1.2345} = 7.05$$

$R_{1(2345)}$ was 0.69, only slightly higher than the r_{12} of 0.68; that is, the correlation between first semester's grade points and second semester's grade points. This does not mean that factors other than the previous record are not useful in estimating second semester's grade points, but rather that these factors are operating in determining first semester's grade points and hence are already accounted for in r_{12}. For seven hundred sixty-six cases, the correlation between predicted grade points and grade points actually earned during the second semester was 0.73.

The author was curious to know to what extent the scholastic success of college students during subsequent semesters could be estimated from past semesters' records only. The number of grade points earned was taken, as in previous calculations, as the criterion of success. For this purpose, the variables may be defined as follows:

$\bar{X}_1$ = Semester for which grade points are to be estimated.
X_2 = Previous semester's grade points.
X_3 = Cumulative grade points up to the semester for which grade points are to be estimated.

Table III gives a summary of results for the last six semesters in college.

The correlations between the estimated grade points and the previous semester's grade points were all higher, with the exception of the eighth semester, than correlations between first semester's grade points and aptitude percentiles, reading percentiles, or high-school record. As might be expected, the correlations between cumulative grade points and estimated grade points for the following semester were usually higher than between the grade points for any given semester and the following semester, although only slightly so. The standard errors of estimate were approximately equal for all multiple-prediction formulae. The multiple R's were all higher than the zero-order

correlations, although not very much higher. Of course, r_{23} was considerably higher in all cases than r_{12} or r_{13}, since the cumulative grade points in the third variable always included the grade

TABLE III.—PREDICTIONS OF GRADE POINTS FOR EACH OF THE LAST SIX SEMESTERS IN COLLEGE ON THE BASIS OF PREVIOUS COLLEGE RECORD

Semesters for which grade points were estimated	Factors used for making estimates		Correlations				Multiple prediction formulae		
	X_2	X_3						$\sigma_{1.23}$	N
X_1	Previous semester's grade points	Cumulative grade points to date, including previous semester's grade points	r_{12}	r_{13}	r_{23}	$R_{1(23)}$	$X_1 =$		
3	2nd	1st 2nd	0.59	0.62	0.90	0.64	$.16X_2 + .26X_3 + 6.93$	7.68	753
4	3rd	1st three semesters	0.65	0.67	0.82	0.69	$.29X_2 + .16X_3 + 6.71$	6.95	502
5	4th	1st four semesters	0.61	0.63	0.81	0.65	$.31X_2 + .13X_3 + 4.02$	7.75	438
6	5th	1st five semesters	0.61	0.56	0.73	0.63	$.42X_2 + .06X_3 + 6.76$	8.07	305
7	6th	1st six semesters	0.60	0.55	0.70	0.63	$.43X_2 + .06X_3 + 6.51$	8.24	259
8	7th	1st seven semesters	0.49	0.65	0.68	0.55	$.10X_2 + .07X_3 + 8.23$	8.28	88

points for the previous semester, and variable 2 was thus always correlated partly with itself. In general, it seems that the simple correlation between the grade points for any given semester and the previous semester is only so slightly below a more complicated multiple R that, if it is necessary to save time, it might well be used as the basis for estimating the grade points for the following

semester. Using only previous record as the bases for prediction, the correlation between predicted grade points and grade points actually earned for the third, fourth, and fifth semesters were 0.63, 0.71, and 0.70, respectively. However, in considering individual students, it always seems safer to have as many previous records as possible.

Incidentally, the author has found that a series of percentiles running from the first semester on, for each student, is an excellent way of noting at a glance whether the student is getting better or worse, or is erratic during his college career. These percentiles are derived from frequency distributions of grade points for each semester and can be revised from year to year, thus making them more and more typical and stable as *N* increases.

CONCLUSIONS

1) High-school record, when reduced to a single summary score, is as useful in estimating future scholastic success in college as aptitude percentiles, reading percentiles, or objective English examination percentiles.

2) Reading percentiles or objective English examination percentiles are about as good for prediction purposes as aptitude percentiles.

3) Previous high-school record and entrance examination records seem to begin to lose their value to a slight degree after a lapse of time of a year or more.

4) As might be expected, it seems safer to depend upon several factors in estimating future scholastic success than to depend upon a single factor such as IQ or college aptitude percentiles.

5) The best single indicator, of those studied, of scholastic success in any given semester is the previous semester's record.

6) Errors of prediction of scholastic success are still fairly high. Correlations in the low 0.60's are gratifyingly useful, but low enough to remind us that in attempting to predict human behavior we are still dealing in probabilities rather than fixed laws. However, whatever the ultimate causes, students do tend to move forward down a fairly predictable, even though somewhat wide, groove. The above formulae often predict the following semester's grade points 'right on the nose.' But with correlations no higher than those obtained from aptitude, reading, or English A

examinations, or from previous record, they are sometimes pretty wide of the mark. Perhaps, if all students always worked up to capacity; if we had some way of knowing accurately how much time, energy, and intelligent application each student devoted to his studies; and if instructors used more objective methods of appraising student achievement, we might still further reduce the errors of our predictions.

SOME COMPARISONS BETWEEN THE ORIGINAL AND THE REVISED STANFORD-BINET SCALES

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There is urgent need for much careful research regarding the comparative values of the Stanford Revision of the Binet Scale (referred to in this article as the 'old scale') and the Revised Stanford-Binet Scale (referred to in this article as the 'new scale'). The studies reported to date in this regard are inadequate to provide a basis for valid judgment. Inasmuch as the old scale reigned almost supreme in this country from 1916 to 1937 as a measuring device for intelligence, especially of the feebleminded, we should be very sure that we have something better before we discard such a serviceable and long-tried instrument. While it is conceded that the old scale has limitations and weaknesses, one wonders if we have adequate evidence of the superiority of the new scale when all factors are considered to justify our discarding the old scale and adopting the new scale.

This article presents results of two studies conducted by the Massachusetts State College in regard to certain comparisons of the two Stanford-Binet Scales. One study, presented in Part I, was conducted in the public schools of Amherst, Mass., and the other, presented in Part II, in the Belchertown State School for the feebleminded at Belchertown, Mass.

PART I

Subjects.—Ninety-eight pupils, forty-nine boys and forty-nine girls, in the public schools of Amherst, ranging in chronological age from seven years, no months, to eleven years, eleven months, were used as subjects. Ten boys and ten girls were selected at each of the age levels from seven to eleven inclusive except year eleven where there were nine of each sex. The subjects were selected at random except for an occasional problem child suggested by a teacher.

Materials.—Complete equipment for the old scale and for Form L of the new scale was used. The scholastic averages of the subjects were obtained directly from the teachers' records, but the marks were not made available to the test administrator

until all the testing had been completed. Marks in reading, language, mathematics and social studies only were used in determining the scholastic averages. The chronological ages were copied from the teachers' registers.

Method.—Each of the ninety-eight subjects was given both the old scale and the new scale. All testing was done by the same individual and always in a private room. In an attempt to control effects of practice forty-nine were given the old scale first and the new scale last and the remaining forty-nine were given the new scale first and the old scale last. The interval between the two tests could not be held entirely constant, but in most cases it was about a week. In a few cases where the interval was greater than two weeks, a half-month was added to the chronological age in the second test. Both mental age and IQ were computed for each individual from the test results of each scale.

Results.—Table I summarizes the data. The mean of the IQ's for the old form is 109.55 and the median is 109.84. The standard deviation is 16.04. For the new scale the mean is 115.42, the median is 117.05, and the standard deviation is 20.32.

It will be noted that the average of the IQ's is above normal for both scales. This is probably due primarily to the fact that the study was made in a college town. It will be noted further that the average IQ for the new scale is 5.87 points higher than the average for the old scale. This would indicate that the new scale is appreciably easier for the type of subject used in this study. A comparison of the standard deviations of the two scales shows that the IQ's of the new scale have a somewhat wider dispersion than the IQ's of the old scale.

In an attempt to secure information regarding the comparative economy of administration of the two scales, accurate records were kept of the time required for testing each subject with each scale. It was found that the average time for administering the new scale was thirty-three per cent greater than for administering the old scale. This difference may be due in part at least to the nature of the subjects and the administrator rather than to the nature of the test itself.

In an attempt to determine the comparative validity of the two scales, the school marks earned during the year in which the study was made were used as the criterion. It is fully realized

that school marks may not be a valid criterion of intelligence, but they afforded the best one available.

TABLE I.—DISTRIBUTION OF THE IQ'S, MEANS, MEDIANS, AND STANDARD DEVIATIONS FOR THE OLD SCALE, THE NEW SCALE, AND THE AVERAGE OF THE TWO SCALES

$N = 98$

IQ's	Old Scale No. of cases	New Scale No. of cases	Average of Old and New Scales No. of cases
65–69	0	1	0
70–74	1	1	1
75–79	2	3	2
80–84	5	2	5
85–89	4	6	3
90–94	7	4	4
95–99	4	3	5
100–104	11	7	10
105–109	16	14	8
110–114	15	6	12
115–119	9	6	15
120–124	5	7	11
125–129	6	12	6
130–134	7	10	5
135–139	2	6	4
140–144	2	4	4
145–149	1	1	1
150–154	1	3	0
155–159	0	1	2
160–164	0	1	0
Mean.....	109.55	115.42	114.58
Median.....	109.84	117.05	112.58
Standard Deviation.	16.04	20.32	17.72

The following Pearson product-moment correlations were secured:

(1) Old Scale IQ's vs. school marks .73 + .032.

(2) New Scale IQ's vs. school marks .78 + .027.

(3) Average IQ's of both scales vs. school marks .78 + .027.

Inasmuch as the correlations between mental test results and scholastic averages usually range between .40 and .70, all these

correlations may be considered significant. It will be noted that the correlation for the new scale is approximately .05 higher than for the old scale. The difference between these correlations is such that there are seventy-nine chances in one hundred of a difference greater than zero between the true correlations. While this does not prove a significant difference between the two correlations, it is probable, at least, that the new scale corresponds somewhat more closely with this criterion. A correlation of .88 was found between the IQ's of the old scale and the new scale, indicating that the two scales are measuring very largely the same thing.

Summary of the indications of Part I.—(1) The new scale correlates slightly better with school marks among somewhat superior children between the ages of seven and eleven years.

(2) The new scale averages higher than the old scale by 5.87 IQ points.

(3) The distribution of IQ's on the new scale show greater dispersion.

(4) Both scales are measuring practically the same thing. —$r \div .88$

(5) It requires about thirty-three per cent more time to administer the new scale than the old scale.

PART II

This study was made with children in the Belchertown (Mass.) State School for the feebleminded. It would appear important that the comparative value of the two scales be determined in feebleminded institutions because of the extensive use of such tests in dealing with subnormal children. For example in Massachusetts it is specified by law that all school children retarded three years must be examined by a State psychological clinic and that the mental age and IQ of such children be determined by the Standford-Binet Scale. Also all juvenile delinquents in Massachusetts are examined by a State psychological clinic and here, again, the Stanford-Binet Scale is used to determine the mental age and IQ. Largely upon these results the clinic advises concerning the treatment of delinquents.

Subjects.—The subjects for this study were fifty inmates of the Belchertown State School. Subjects were selected who had not taken the test for at least three years in order to control

practice effects. None of the subjects had ever been tested by the new scale. The mental ages of the subjects ranged from three to eleven years inclusive and all chronological ages were over sixteen.

Procedure.—Both the old scale and the new scale (Form L) were given to each subject by the same examiner. To one-half of the subjects the old scale was given first and to the other half old scale second. This procedure was used in order to control and somewhat evaluate the significance of practice effects. The interval between the two tests ranged from one to two weeks. The time required to administer each test ranged from one hour to one and one-half hours depending upon the scale being used, the mental age and the general attitude of the subject, and the rapport between the subject and the examiner.

TABLE II.—DISTRIBUTION OF IQ'S, WITH MEANS, MEDIANS, AND STANDARD DEVIATION FOR THE OLD SCALE, THE NEW SCALE, AND THE AVERAGE OF THE TWO SCALES.
$N = 50$

IQ's	Old Scale No. of cases	New Scale No. of cases	Average of Old and New Scales No. of cases
20–24	1	1	1
25–29	0	1	0
30–34	3	0	2
35–39	6	5	5
40–44	4	2	3
45–49	8	6	6
50–54	5	10	5
55–59	8	3	5
60–64	6	5	6
65–69	4	5	6
70–74	5	8	6
75–79	0	2	2
80–84	0	2	0
Mean.....	52.28	56.50	54.39
Median.....	52.50	55.75	54.5
Standard Deviation.	12.30	14.08	13.56

Results.—Table II presents a summary of the results. Inasmuch as these subjects had no school marks because of too low

intelligence to attend school, correlations were not computed with this criterion. Accordingly, relationships between the two scales were secured primarily by determining to what extent they measure the same thing. This was done by correlating the IQ's of one scale with the IQ's of the other scale.

A Pearson product-moment correlation of .94 + .01 was found between the IQ's of the old scale and the IQ's of the new scale as secured directly from the tests. This would indicate that the two scales are measuring practically the same thing. This correlation is as high as is usually found between the different forms of the same test. The IQ's on record in the institution computed about three years earlier by using the old scale were then correlated with the IQ's in this study secured from the old scale. This means the same test was repeated by a different administrator after an interval of three years. This correlation was .93 + .01. These correlations indicate that the difference between the old scale and the new scale has practically the same influence upon results as does a three-year interval and a different administrator in repeating the same test.

In comparing IQ's of the first and second testing, regardless of which scale was used first, it was found that the second scale gave an average of one point higher IQ than the first scale used. This increase was apparently due to practice. A correction for this practice effect was made by adding one point to each IQ of the first test. The correlation between the corrected IQ's was found to be .95 + .10. This would appear to be the best measure of similarity between the old scale and the new scale. The negligible increase of one point in IQ from practice received in taking the other scale appears small, but it should be noted that these are feebleminded children. Table II shows that the average IQ for the old scale is 52.28 while the average IQ for the new scale is 56.50, indicating a difference of 4.22 IQ points in favor of the new scale. The standard deviation of the old scale is 12.30, and of the new scale 14.08. Time records were kept for each child tested. The average time for administering the new scale was about twenty-six per cent greater than for administering the old scale.

Summary of indications of Part II.—(1) The most significant finding in this study is that the old scale and the new scale

measure so nearly the same thing then given to feebleminded children. $r = .94$

(2) Twenty-six per cent more time is required to administer the new scale.

(3) Practice effects after two weeks were negligible.

(4) The new scale averages higher than the old scale by .422 IQ points.

(5) The distribution of IQ's on the new scale shows greater dispersion.

GENERAL SUMMARY OF PART I AND PART II

1) The most significant finding in these two studies perhaps is that the two scales measure so nearly the same thing. The correlation of .88 between the IQ's of the old and new scales for slightly superior children, and of .94 between the IQ's of the old and new scales for feebleminded children, both indicate that the two scales are measuring approximately the same thing, but more nearly so in the case of the feebleminded.

2) If school marks are accepted as a criterion of validity for an intelligence test, the new scale is probably more valid as a measure of intelligence in testing slightly superior children between the ages of seven and eleven years. This criterion was not available for the feebleminded group.

3) The new scale tests higher by an average of 5.87 points in IQ for slightly above normal children and of 4.22 IQ points for feebleminded children.

4) Both studies show greater dispersion of IQ's for the new scale.

5) It required approximately twenty-eight per cent more time to administer the new scale.

A MACHINE METHOD FOR COMPUTING THE CRITICAL RATIO OF THE DIFFERENCE BETWEEN MEANS

QUENTIN W. FILE

In many controlled observations, two groups of equal size are observed. Data are gathered for the purpose of determining if varying a given condition will produce significant differences between the experimental group and the control group with respect to other variables. When a considerable number of factors are considered, statistical tests of these differences can become extremely laborous. The following method is suggested as a means for minimizing this labor. The only requirements are that the number of cases in each sample be the same and that the samples be uncorrelated.

The time-saving qualities of this method depend upon the combination of several formulae into a single workable equation. By using this method the time required to compute a critical ratio of the difference between two means is only about twenty-five per cent as much as would be required if each factor were computed separately. The writer feels that it is especially valuable for the analysis of test item discrimination where previous assumptions as to the correct answers to individual items seem unwise. By obtaining the upper and lower portions of any sample of variables with respect to a given criterion, no assumptions need be made as to the best answers to individual items until the analyses have been completed.

The basic formula for the critical ratio of the difference between means is

$$\mathrm{CR}_{M_1-M_2} = \frac{M_1 - M_2}{\sigma_{M_1-M_2}} \tag{1}$$

where M_1 and M_2 are the means of Samples 1 and 2, respectively, and $\sigma_{M_1-M_2}$ is the standard error of the difference between these means.

Breaking each of these quantities into their component parts, the following formulae are obtained:

$$M_1 = \frac{\Sigma X_1}{N_1} \tag{2}$$

where ΣX_1 is the sum of the scores in Sample 1 and N_1 is the number of cases in the sample. Similarly $M_2 = \frac{\Sigma X_2}{N_2}$.

$$\sigma_{M_1-M_2} = \sqrt{\sigma_{M_1}^2 + \sigma_{M_2}^2} \tag{3}$$

where σ_{M_1} and σ_{M_2} are the standard errors of their respective means. The reader will recall that the requirements for this method are that the samples be uncorrelated and the number of cases in each sample be the same.

The standard error of M_1 is calculated by the formula,

$$\sigma_{M_1} = \frac{\sigma_1}{\sqrt{N}},$$

when the sample consists of thirty cases or more, and

$$\sigma_1 = \frac{1}{N}\sqrt{N\Sigma x_1^2 - \overline{\Sigma x}^2} \tag{4}$$

By substituting Formulae 2, 3, and 4 back into Formula 1, we obtain

$$\mathrm{CR}_{M_1-M_2} = \frac{\frac{\Sigma x_1}{N} - \frac{\Sigma x_2}{N}}{\sqrt{\frac{1}{N^2}\left(\frac{\Sigma x_1^2 - \overline{\Sigma x}^2}{N}\right) + \frac{1}{N^2}\left(\frac{\Sigma x_2^2 - \overline{\Sigma x}^2}{N}\right)}}$$

Simplifying

$$\mathrm{CR}_{M_1-M_2} = \frac{\sqrt{N}(\Sigma x_1 - \Sigma x_2)}{\sqrt{N\Sigma x_1 - \overline{\Sigma x}_1^2 + N\Sigma x_2^2 - \overline{\Sigma x}_2^2}}$$

Thus, when all factors are placed under the radical,

$$\mathrm{CR}_{M_1-M_2} = \sqrt{\frac{N(\Sigma x_1 - \Sigma x_2)^2}{N\Sigma x_1^2 + N\Sigma x_2^2 - \overline{\Sigma x}_1^2 - \overline{\Sigma x}_2^2}} \tag{5}$$

Formula 5 applies equally well to raw score data and to data which are grouped with identical intervals on both axes. No treatment of the size of the intervals is necessary since these values algebraically cancel each other.

CR values are easily obtained on a rotary dial calculating machine in the following way:

1) Compute ΣX and ΣX^2 for each sample, i.e. ΣX_1, ΣX_2, etc.

2) Place the N of the samples in the calculating machine keyboard. The N is the number of cases in either sample.

3) Compute the difference between ΣX_1 and ΣX_2 mentally, OR with a pencil, and look up this value in a table of squares. Multiply the obtained value by the N already in the calculator keyboard. Record the result and clear the dials but not the keyboard.

4) Multiply N by ΣX_1^2 and by ΣX_2^2, accumulating products. Clear the keyboard and subtract out $\overline{\Sigma X_1}^2$ and $\overline{\Sigma X_2}^2$ and record the result.

5) Divide the result obtained in Operation 3 (by the result obtained in Operation 4).

6) Look up this value in a square-root table. The result obtained will be the critical ratio of the difference between the means of the two samples compared.

BOOK REVIEWS

SIR RICHARD LIVINGSTONE. *On Education: The Future of Education; Education for a World Adrift.* New York: The Macmillan Co., 1944, pp. 285.

This volume consists of two books issued separately in England. In "The Future in Education," the author considers certain deficiencies in English education together with desirable changes. "The pressing problem is to give the masses of the nation some higher education . . . " This should include study of (1) human ideals and achievement, and (2) the material universe (science). It is held that, for full appreciation and the most fruitful study of history, literature and politics, experience of life is necessary. It follows, therefore, that (1) the majority can only study these subjects satisfactorily in their adult years; (2) without an extended system of adult education it is impossible to have an educated nation; and (3) everybody should have an opportunity for methodical study after having experience of life.

In "Education for a World Adrift," the author expands his ideas on educational aims and ideals. Attention should be devoted not only to providing more education, but also to the nature of what is to be taught. In addition to imparting knowledge necessary to living and to teaching people to use their brains, other things must be considered. "Most important of all is what a man believes, what he thinks good and bad, whether he has clear values and standards and is prepared to live by them." There is need, therefore, of values and standards which are founded in a philosophy of life. Various chapters deal with the problem, use of history and literature in forming values and standards, the basis of a spiritual philosophy of life, obstacles presented by the examination system and over-specialization, and education for citizenship.

These two essays should be read carefully by all those interested in educational practices. The analyses and the arguments are clearly presented. Whether or not the reader agrees with the solutions suggested, he will be stimulated to serious thinking about the problem of postwar education. MILES A. TINKER

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WILLIAM BOYD, Editor. *Evacuation in Scotland.* London: University of London Press, 1944, pp. 224.

This treatise is a record of events and experiments concerned with wartime evacuation and the resulting social and educational problems. Part of the report is an historical account of the various aspects of the evacuation. This is followed by reports on three sociological studies. Data for two of these were obtained from education graduates who had had firsthand experience with the evacuation. The other is concerned with evacuation experiences of a representative school population. The rest of the material in the book consists of selected educational experiments originating in expedients devised by directors of education and by teachers to provide some kind of schooling for evacuees and for pupils who remained at home. Some of the educational programs were temporary, but others have promise of permanence.

This book is one of the publications of the Scottish Council for Research in Education. This organization has been thoroughly aware of its responsibilities and its opportunities during the wartime crisis. Wholehearted approval should be given the farsighted and competently conducted programs sponsored during recent years by the Scottish Council. In addition to improving the welfare of Scottish children, much of the information accumulated provides valuable information to all those interested in child guidance and in certain educational problems.

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SISTER JUSTA MCNAMARA. *The Teachability of Certain Concepts in Modern European History in the Secondary School.* Baltimore: The Johns Hopkins Press, 1943, pp. 172.

Recent investigations have emphasized the failure on the part of a large percentage of high-school students to measure up to expectations in actual school achievement, especially after a moderate lapse of time. The recent discussion of the results of the tests in American history has brought the matter to a focus. There is common agreement that it is important for pupils leaving school to have an adequate understanding of concepts gained from a study of Modern European History, with a view

to lessening race prejudice through better understanding of the problems, customs and viewpoints of European nations. This excellent dissertation is an experimental study of a limited area of this general field, and is a sane, well-written contribution.

More specifically the chief point under consideration is that of the best grade placement of the course in Modern European History, in view of the probabilities of successful achievement, of the grade placement of related subjects including American history, and of the age at which pupils leave school. The brief review of the pertinent literature is interesting and illuminating. The materials of the experiment were built up under actual classroom conditions. Ten teachers participated. The testing combined objective and essay techniques, and both appear to be used with a view to validity, as distinguished from mere reliability, in the evaluation of achievement of the goals aimed at. The procedure is well planned, and the conclusions appear to be well justified. From the standpoint of the quality of mastery of essential concepts, it seems advisable to place this subject in high school in the eleventh grade. The reasons for the definitely greater achievement in this grade than in the ninth or tenth were the higher mental age of pupils, and the greater school experience upon which they have to draw. Chronological age was found not to be an important consideration as distinguished from mental age and contributory school experience. Neither was socio-economic status.

As suggested by the author, further research might well be conducted upon the relation of teacher personality, operating through improved motivation, upon pupil achievement.

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